Forest plant biological diversity in Liangshui Nature Reserve

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Abstract Investigations of forest plant biological diversity were conducted in Liangshui Nature Reserve, Xiaoxing'an Mountains in eastern Heilongjiang Province. Six samples were selected to initiate fieldwork in spring, summer and autumn. Two samples were added to the whole experiment. Results showed that plant biological diversity in the natural reserve varied with seasons as well as plant growth forms. Generally the highest diversity values occurred in spring in the communities. Herb species had richer diversity than those of either shrub species or wood species. Species richness, diversity and evenness were quoted in the analysis.

Key words: Species diversity, Growth form, Nature reserve

Introduction

Biological diversity or biodiversity is characteristic of diverse and living entity group or class. Diversity exists at three different levels: within species (genetic), species and ecosystem levels. It is the basic characteristic of living system (Solbrig 1991).

Unfortunately, exploding human populations, 6 billion people are degrading the environment at an accelerating rate, especially in developing and undeveloped countries. Between 20 and 25 percent of all the species on Earth may disappear within the next 30 to 40 years. Meanwhile worldwide science is discovering new uses for biological diversity in ways that can relieve both human suffering and environmental destruction. But the fact is that much of the diversity is being irreversibly lost through extinction caused by the destruction of natural habitats, probably lots of them disappeared before we know them. It is becoming more and more urgent that biological diversity must be treated more seriously as a global resource, to be indexed, used, and above all, preserved. In all these years of research in genetics, systematic, evolution and ecology has produced a large bulk of data on the importance of diversity for the proper function of organisms and ecosystems. However, we still lack comprehensive and rigorous theories for biodiversity, and biodiversity conservation.

Liangshui Nature Reserve is rich in species of plants, animals, insects and microbes in its abundant preserved original Korean pine forests. Plant biological diversity investigation and field works were conducted from spring, summer to autumn, from herb, shrubs to woods. The objective is to reveal the current state of plant biodiversity inventory and understanding of preservation and utilization there.

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Materials and methods

In the large area of origin forests, six forest communities were selected out as experimental samples to indicate the biological diversity in different gradients of disturbance. Spruce forests, linden-Korean pines, birch-Korean pines, oak-Korean pines, artificial Korean pines and artificial larches. Another artificial larches and firs were also added to the work in autumn. The climatic vegetation type is broad-leaved/Korean pines, which was in evolution and acclimated to the habitat in thousands years. Liangshui Nature Reserve that belongs to Changbai Flora, lies in the center of the distribution of Korean pine (*Pinus koraiensis*). The forests were perfectly protected and the forest coverage reached 96%. The investigations were from early spring to late autumn in this area and biodiversity data included herb species, shrub species and wood species in each community.

The area of each sample was 20 m × 20 m. Detail investigations were in 2 m × 2 m small plots, 25 plots were randomly distributed in each sample. Investigation for wood species was in the area no less than 100 m^2, and that for shrub and herb species was in 25 quadrats of 1 m^2. Fieldwork included the list and individual number of all plant species and ferns, trunk diameter and height of trees, canopy density, soil condition, altitude, direction and slope of the samples.

α Biodiversity indices were adopted in the analysis. Richness index N_0 was the number of species in the same-scaled communities.

Diversity index were proposed by Hill in 1973 and developed to Shannon index.

$$H'=-S(P_i \ln P_i)$$

Where P_i is the individual percentage of species i and s is the number of species.

Evenness index was based on Pielou's (1975, 1977) and adopted as $E_1=H'/\ln(s)$.

Other similar α biodiversity indices were not discussed in this article. β biodiversity is the rate and arrange of biodiversity change from one habitat to another in one gradient. Goldsmith-Harrison proposed this index:

$$C_N = \frac{ZjN}{(aN+bN)}$$

Where *aN* is individual number in habitat a; *bN* is individual number in habitat b; *jN* is total number of the same species with less individuals in the two habitats.

γ biodiversity, which is called overall biodiversity is the total of α biodiversity and β biodiversity. It is the biodiversity based on the scale of landscapes, also called landscape biodiversity.

H' was accepted to stand for γ biodiversity in Liangshui area, where there forest compartments and patches were chosen to be basic units.

Data were processed by the software appended to Statistic Ecology by Jhon and James (1988).

Results and discussion

General information about the samples was collected during the field work as shown in Table 1.

Table 1. General information of the samples

Community	Crown woods	Altitude /m	Direction and slope	Canopy density	Stand section area /m²·m⁻²
Spruce forests	6 spruces , 2 birches, 1 larch	325	Flat, 0°	0.7-0.8	5.72
Linden-Korean pines	8 pines, linden, elm	415	South, 15°	0.6-0.75	4.27
Birch-Korean pines	7 pines , 1 birch, fir, maple	485	West, 5°	0.6-0.7	13.48
Oak - Korean pines	7 pines, oak, linden	545	Southeast, 28°	0.6-0.7	17.51
Artificial Korean pines	9 pines, 1 larch	375	West, 15°	0.7-0.8	12.27
Artificial larches	9 larches, 1 corktree	390	South, 5°	0.65-0.75	6.8

Community	Dominant species Height and BD	Soil condition	Main species in regeneration	Main species in succession
Spruce forests	Spruce, 8 m & 10.5 cm White birch, 10m & 14 cm	Deep soil layer and wet, a little litter	Spruce, Korean pine, fir	
Linden-Korean pine	Pine, 13 m & 20.8 cm	Deep soil layer with much humus and litter	Korean Pine, Linden, Maple	Amur maple
Birch-Korean pine	Pine, 23 m & 66 cm Birch, 21 m & 40 cm	Very deep soil layer, much humus and litter	Korean Pine, Fir	Amur maple, ManChurica maple
Oak-Korean pine	Pine, 19.8 m & 34.8 cm	Shallow soil layer with Rocks, much litter	Korean pine, fir, oak, Maple	Manchurica maple, Deutzia
Artificial Korean pines	Pine, 11 m & 13.7 cm, Larch, 17 m & 26 cm	Deep soil layer, much litter, poor humus	Spruce, Korean pine, Fir	Deutzia
Artificial larches	Larch, 15.8 m & 16.5 cm, Corktree, 10 m & 14 cm	Deeper soil layer, abundant litter, rich humus	Korean pine, acanthopanax	Maple, Manchurica ash

Liangshui Nature Reserve is an experimental forest farm of Northeast Forestry University. It is approved to be a national park and preserved as an experimental and research center. Besides original Korean pines, Korean pines, spruces, larches, firs, scotch pines and some mixture forests were also planted in this area.

7 wood species appeared in Spruce forest, and they were *Betulla platyphylla*, *Larix gmelinii*, *Picea koraiensis*, *Picea jezoensis*, *Pinus koraiensis*, *Abies nephrolepis*, *Fraxinus manshurica*. 8 wood species were found in Linden-Korean pines, they were *A. nephrolepis, P. koraiensis, Acer tegmentosum, Acer mono, Quercus mongolica, Betulla costata, Ulmus laciniata, Tilia amurensis*. 9 wood species presented in Birch-Korean pines. There were *P. koraiensis, F. manshurica, A. tegmentosum, T. amurensis, A. mono, Acer ukurunduense, A. nephrolepis, U. laciniata, B. costata*. 12 wood species showed in Oak-Korean pines, where there the highest richness were obtained, *P. koraiensis, T. amurensis, Tilia manshurica, A. mono, A. tegmentosum, A. ukurunduense, F. manshurica, Q. mongolica, U. laciniata, Picea koraiensis*. And 8 wood species presented in artificial Korean pines, hundreds spruce seedlings with about 50-cm height appeared in the community. 9 wood species presented in artificial larches, *Phellodendron amurense* showed in the community. Oak-Korean pines had the highest biodiversity of wood species and Artificial Korean pines had the lowest

biodiversity and evenness. Birch-Korean pines had the highest evenness. Although Oak-Korean pines habitat was poor and a lot of rocks present there, some species adapted to the habitat and were distributed evenly, topped the biodiversity. Spruce seedlings were too rich in Artificial Korean pines caused the lowest biodiversity and evenness. See Fig. 1.

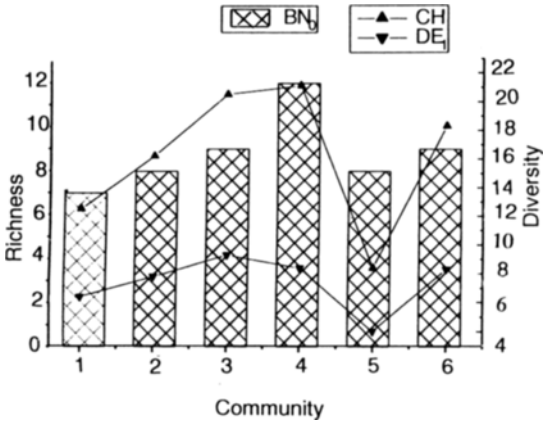

Fig. 1. Diversity indices of wood species in the year

Numbers 1, 2, 3, 4, 5, 6 on X-axis respectively represented Spruce, Birch-pines, Linden-pines, Oak-pines, Artificial pines and Artificial larches. N_0, H', E_1 respectively meant richness, diversity and evenness. (These explanation can be also used for Fig. 2- 4).

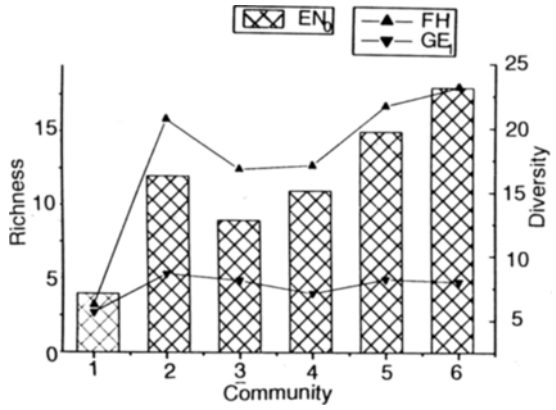

Fig. 2. Diversity indices of shrub species in the year

Artificial larches had 18 shrub species in the year, which was the highest richness comparing with only 4 shrub species in Spruce forests, which was the lowest in richness. The main shrub species appeared in Artificial Larches were *Berberis amurensis, Deutzia glabrata, Ribes manshurica, Ribes triste, Philadelphus schrenkii , Evonymus pauciflorus, Evonymus sacrosancta, Aralia manshurica, Acanthopanax senticosus, Syringa amurensis, Lonicera chrysantha, Menispermum dahuricum.* Only *Lonicera caeurulea, Ribes triste, Deutzia glabrata* and *Spiraea ussuriensis* were found as shrub species in Spruce forests. Spruce forests also had the lowest biodiversity and evenness (Fig. 2). Artificial larches had the highest diversity, while Linden-Korean pines had highest evenness. Artificial larches was not only rich in species but also had an even distribution of individuals.

For herb species, the highest richness was in Artificial Korean pines and Artificial larches (Fig. 3). The two communities were close and had similar habitat, shared many species, such as *Urtica laetevirens, Urtica anqustifolia, Rumex acetosella, Pseudostellaria sylvatica, Pseudostellaria rupestris, Actaea spicata, Anemone udensis, Cimicifuga dahurica, Thalictrum baicalense, Caradamine leucantha, Astilbe chinensis, Chrysosplenium alternifolium, Filipendula palmata, Potentilla chinensis, Impatiens noli, Polemonium liniflorum, Rubia chinensis, Galium dahuricum, Vicia unijuga, Viola collina, Polemonium liniflorum, Smilacina dahurica, Gagea hiensis*. Some ferns also grew well in the two humid communities. They were *Adiantum pedatum, Athyrium brevifrons, Athyrium spinulosum, Dryopteris austrica*. Some bryophyte such as *Dicranum scoparium, Dicronodontium denudatum, Oncophorus wahlenbergii, Anomodon minor, Necker pe..iata* were common in the forests.

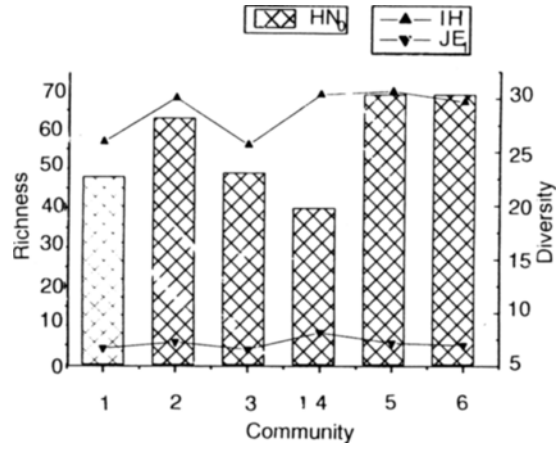

Fig. 3. Diversity indices of herb species in the year

In Artificial Korean pines, the humidity is so high that a lot of lichen reached to the crown of the trees. Most of them were *Pamelia caperata, Pamelia saxatilis, Usnea longissima.* There were 69 herb species in each community. Artificial Korean pines had a higher diversity and evenness than those of Artificial larches. Oak-Korean pines had the highest diversity with the lowest richness and highest evenness. The community lied on a dry area with high altitude and poor soil condition. Herb species were not so rich to live and survive on the poor soil.

From the investigation in the three seasons, Artificial larches had the highest richness in species among all the communities (Fig 4). 96 species were found presented in the community around the year, including some species such as *Phryma leptostachya*, which is the indicative species in original

Korean pines. The larches were planted on a cutover 35 years ago. It was surrounded by original Korean pines and some other broad leaf and conifer forests. Rich soil condition and enough expose of sunshine caused the spread of a lot of pioneer species as well as some species needs shadow under the broad leaf trees, especially some herb species were very abundant. The individuals were about thousands, while other species had only one or two individuals. Oak-Korean pines took the highest diversity and evenness although there were not so many species in the communities as those in Artificial larch forest. The individual numbers and species number made it so. Oak-Korean pines were in the center of the reserve and were surrounded by non-disturbed original broad-leaved-Korean pines. But the habitat was too adverse for most species to enter and spread in the Oak-Korean pines. Some dry resistant species such as *Rhododendron dahuricum* and *Q. mongolica* were growing well on the habitat.

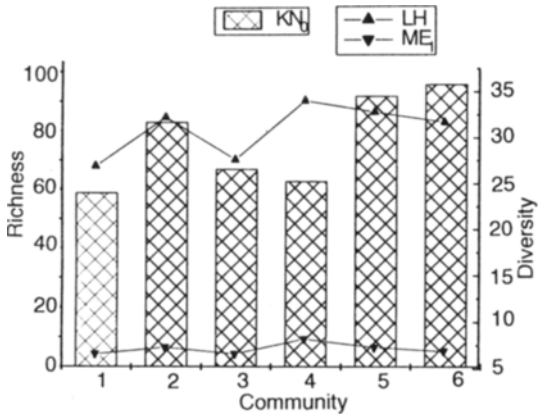

Fig. 4. Diversity indices of the communities in the year

From the investigation on biodiversity in three seasons in the year, the highest species richness appeared in spring in all the communities. It is also interesting to see that species richness did not reach the top value in summer, the growing season in Liangshui. Richness in summer even was lower than that in autumn in some communities. Because there were some early-spring species, which were short-lived plants, only appeared in spring and disappeared soon after. This kind of plants can take enough sun shine before the trees leaf out to survive the cold weather during the melting of snow. The common species were *Convallaria keiskei, Anemone amurensis, Corydalis repens, Eranthis stellata, Enemion raddeamum, Adoxa moschatellina, Campanunda punctata, Polemonium liniflorum, Adonis amurensis, Polygonatum humile, Paris verticillata, Carea ussuriensis*. Early-spring plants played an important role in species richness in this area and finally affected the richness in three seasons. It is possible to conclude that investigation on plants biodiversity should begin in early spring and continue the work until the end of plant growth in autumn. See Fig. 5.

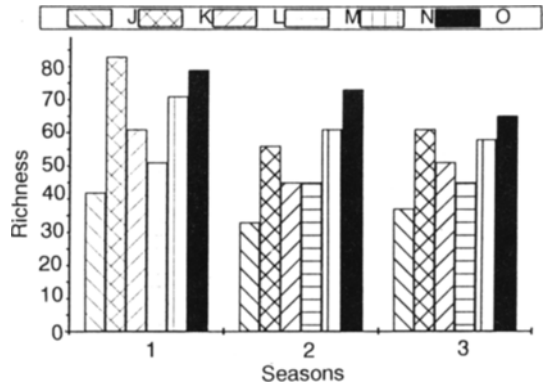

Fig. 5. Species richness of the communities in three seasons

J, K, L, M, N, O respectively represented Spruce, Birch-pines, Linden-pines, Oak-pines, Artificial pines and Artificial larches. Numbers 1, 2, 3 on X-axis meant spring, summer and autumn.

Plant biodiversity varied with seasons. Most of the investigated communities had a higher biodiversity in spring than that either in summer or autumn. Fig. 6 also revealed that biodiversity in some communities reached the lowest values in summer, the growing season for most plants. This work showed that biodiversity work should not only focus on species richness, species individual distribution was sometimes more important in a community. Plant richness and biodiversity in original broad leave Korean pines were promising. The average values from original Korean pines approved the protection of the forests and encouraged more work and study to be done.

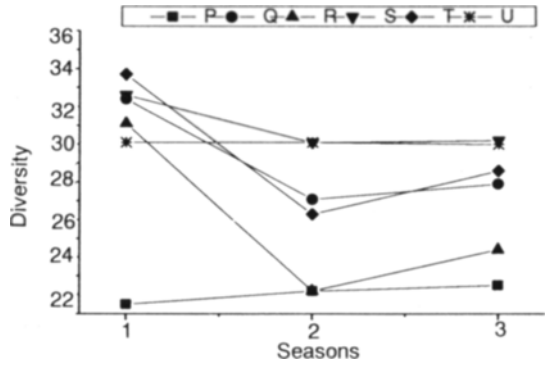

Fig. 6. Biodiversity of the communities in three seasons

P, Q, R, S, T, U respectively represented Spruce, Birch-pines, Linden-pines, Oak-pines, Artificial pines and Artificial larches. Numbers 1, 2, 3 on X-axis meant spring, summer and autumn.

Two other communities, firs and artificial larches were added to the fieldwork in autumn. Plants in firs did not have so much sunshine and it is very humid inside the forests. Species richness was not so good, and the dominant wood species was *Abies nephrolepis*. Hundreds of fir seedlings were found on the ground. Most herb species were from Cyperaceae family, such as *Carex callitirchos* and *Carex rhynchophysa*. Artificial larch forest was planted about 20 years ago and was surrounded by farm fields, oaks and wetlands. 83 species appeared in the larches, which was the highest in one season. It is speculated that more species appeared in spring and summer. It also means that disturbance, especially appropriate disturbance, artificial and natural, can increase species richness and biodiversity. The point is how to measure the disturbance and in which way to disturb the forests so that it can go on the track to benefit all sides as possible as it can, the environment and economy.

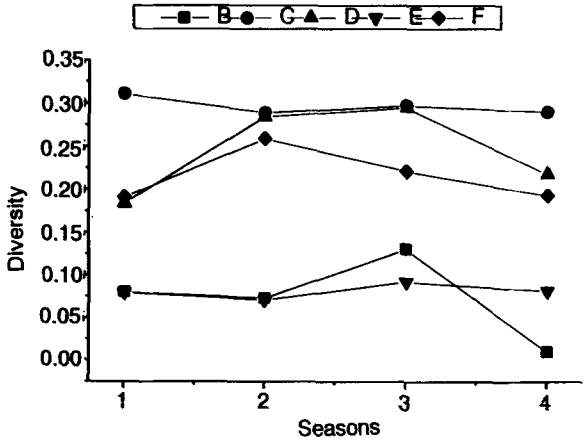

Fig. 7. β diversity in three seasons and whole year in the communities comparing with artificial Korean pines

B, C, D, E, F respectively represented spruce, linden-pines, birch-pines, oak-pines and artificial larches. Numbers 1, 2, 3, 4 meant spring, summer, autumn and whole year.

Comparing with Artificial Korean pines, Linden-Korean pines had the highest β diversity meaning a wide difference between them, Oak-Korean pines had the lowest β biodiversity meaning the least difference between them. Even artificial larches was nearby artificial Korean pines and had a similar habitat sharing many species, they did not show a close relationship with each other from β biodiversity. γ biodiversity from forests patches and compartments in the reserve was higher than that in secondary forests on Maoer Mts.

Original Korean pine forest was regarded as the most stable and productive forests in eastern Heilongjiang Province. It has very high ecological and economical benefits. But the species richness and biodiversity in original Korean pines were not the highest comparing with other forest types. Diversity and productivity did not have an absolutely relation with stability. To preserve original Korean pines can keep an original habitat for plants species to survive and reproduce which led to the increase of species richness.

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References

Biological Diversity Committee of Chinese Academy of Science. 1991. Translations of Biological Diversity (1). Beijing: China Science and Technology Press, China

Clements, F.E. 1976. Plant succession: An analysis of the development vegetation. Carnegie Inst. Pub, 242, Washington D. C.

Chen Linzhi, *et al*. 1993. China's biological diversity-current situation and protection strategy, Beijing: Science Press, China.

Hill, M.O. 1973. Diversity and evenness: an unifying notation and its consequences. Ecology, **54**: 427-432.

Jhon, A.L. and James, F.L. 1990. Statistical ecology. Huhehaote: Inner mongolian University Press, China.

Northeast Forestry University. 1984. Fundamental materials of Liangshui Natural Reserve. Harbin: Northeast Forestry University Press, China

Mc Neely, J.A. 1991. Protected worldwide biological diversity. Beijing: China Environmental Science Press, China

Pielou, E.C. 1975. Ecological diversity, Jhon Wiley & Sons Inc.

Pielou, E.C. 1985. Mathematics ecology. Beijing: Science Press, China

Pielou, E.C. 1966. Shannon扭 formulas as a measure of species diversity it use and misuse. Amer. Nature, **100**: 463-465

Simpson, E.H. 1949. Measurement of diversity. Nature, **163**: 688

Solbrig, O.T. 1991. From genes to ecosystems: a research agenda for biodiversity, IUBS, Paris

Solbrig, O.T. 1991. Biological diversity--related scientific issues and cooperation research suggestions, Translations of Biological Diversity (1). Beijing: China Science and Technology Press

Zhou Xiaofeng. 1991. Orientation study on forest ecological system. Harbin: Northeast Forestry University

Zhou Xiaofeng. 1982. Planting conifers and protecting broadleaves--the way to recover broadleave-korean pines. Journal of Northeast Forestry University, **10** (suppl. issue)